MASTER OF SCIENCE
IN
METEOROLOGY AND PHYSICAL OCEANOGRAPHY

MODELING STUDIES OF THE EFFECTS OF SEASONAL WIND FORCING AND THERMOHALINE GRADIENTS ON THE LEEUWIN CURRENT SYSTEM

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A high-resolution, multi-level, primitive equation ocean model is used to investigate the effects of seasonal thermohaline gradients and wind forcing in the generation of currents and eddies off the western and southwestern coasts of Australia. Additionally, an investigation of the generation mechanisms for undercurrents in the region is conducted.

Model results demonstrate the roles of seasonal thermohaline gradients, wind forcing, and North West Shelf waters in the Leeuwin Current System. While the basic flow is poleward and eastward off the western and southern coasts, due to strong thermohaline gradients, there is significant variability in the flow from the seasonal nature of the wind forcing and the onset of the North West Shelf waters. Model results also indicate that an equatorward (westward) undercurrent off the western (southwestern) coast of Australia is generated and maintained due to the conservation of mass continuity in response to an alongshore thermohaline gradient at deeper levels.

DoD KEY TECHNOLOGY AREA: Modeling and Simulation

KEYWORDS: Primitive Equation Model, Leeuwin Current System, Currents, Meanders, Eddies, Filaments

SEASONAL VARIABILITY IN THE CALIFORNIA CURRENT, A DIECAST MODEL STUDY

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The high resolution DIECAST ocean model, with improved physics, is used to simulate the annual cycle of mesoscale variability in the California coastal region. Model improvements include reduced numerical dispersion, an annual cycle of climatological wind stress forcing enhanced in magnitude near the coastal headlands, and barotropic and baroclinic boundary inflows and outflows. A six year simulation produced results in general agreement with recent observations of the annual cycle in the California Current although the gradients of sea surface temperature and dynamic height are generally stronger, and show more structure than observed. The stronger gradients indicate increased coastal upwelling and produced faster geostrophic currents than observed. A region of maximum Eddy Kinetic Energy (EKE), originally formed in the upper ocean over the continental slope in late spring, migrates westward on a seasonal timescale consistent in magnitude and phase with observations. At the same time, the EKE spreads vertically into the deep ocean, decreasing the surface EKE west of about 126°W as recently documented in the literature. Deficiencies in the simulation include some artificial influences from the incompletely open western boundary, an exaggerated response of the surface circulation to the Mendocino escarpment and the absence of a significant poleward surface current along the coast in winter.

DoD KEY TECHNOLOGY AREA: Other (Physical Oceanography)

KEYWORDS: California Current, Numerical Ocean Modeling

A COMPARISON OF BULK AERODYNAMIC METHODS FOR CALCULATING AIR-SEA FLUX

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The Louis et al. (1982) bulk aerodynamic method for air-sea flux estimates is currently used in mesoscale models such as COAMPS, while the TOGA-COARE method is a state-of-the-art flux parameterization involving recent findings in surface layer meteorology, and has been proposed as a replacement to Louis. The Louis and TOGA-COARE methods were compared to direct observations during ACE-1.

Results from both methods compared well to observations for momentum flux. For sensible and latent heat flux, both methods showed good agreement in low flux regimes and underestimated the fluxes at higher values. Calculation of the transfer coefficients required to match observations indicated that the bulk transfer coefficients do not increase rapidly enough for z/L values less than –0.5. In the high wind regime, the transfer coefficients were very sensitive to static stability. The COARE method was superior to the Louis method for sensible heat flux estimates while the Louis method was better for latent heat flux. A sensitivity test was done to use the COARE roughness length parameterization in the Louis method. This resulted in slight improvement in sensible heat flux estimates for highly convective conditions. Latent heat flux was overestimated by the modified Louis parameterization in the same manner as the COARE algorithm, indicating that specification of the latent heat roughness length requires further study.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation, Other (Meteorology and Oceanography)

KEYWORDS: Air-Sea Flux, Bulk Parameterization, Coupled Ocean Atmosphere Mesoscale Prediction System (COAMPS), Mesoscale Modeling

REMOTE MEASUREMENT OF AEROSOL OPTICAL PROPERTIES USING THE NOAA POES AVHRR DURING ACE-1, TARFOX, AND ACE-2

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A radiative transfer algorithm in the solar wavelengths for the NOAA POES AVHRR is presented for the cloud-free, marine atmosphere. This algorithm combines linearized, single-scattering theory with an estimate of bi-directional surface reflectance. Phase functions are parameterized using an aerosol distribution model and the ratio of radiance values measured in channels 1 and 2 of the AVHRR. Automated cloud screening and sun glint removal is included. Retrieved satellite aerosol optical depth (AOD) is compared to surface measured sunphotometer AOD collected during the International Global Atmospheric Chemistry (IGAC) Project's Second Aerosol Characterization Experiment (ACE-2) from June 16 to July 25, 1997. The comparison data set has a correlation coefficient of 0.88 with a standard error of 0.02 at both channel 1 and 2 wavelengths. Regional aerosol properties are examined with an emphasis on the differences between the ACE-1, TARFOX and ACE-2 regions. ACE-1 and ACE-2 regions have strong modes at AOD at around 0.1, but ACE-2 tails toward higher values consistent with urban and dust aerosol intrusion. The TARFOX region has a noticeable mode at AOD around 0.2, but has significant spread of AOD values consistent with the varied aerosol constituents in that area.

DoD KEY TECHNOLOGY AREAS: Battlespace Environments, Environmental Quality

KEYWORDS: Radiative Transfer, Advanced Very High Resolution Radiometer (AVHRR), Aerosol Optical Depth (AOD), First Aerosol Characterization Experiment (ACE-1), Tropospheric Aerosol Radiative Forcing Observational Experiment (TARFOX), Second Aerosol Characterization Experiment (ACE-2)

OBSERVATION AND ANALYSIS OF COASTALLY TRAPPED WIND REVERSALS

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During the warm season (April-September), the California coast is under the influence of persistent northwesterly flow. Periodically, this flow is replaced by a narrow band of southerly winds along the coast. The transition to southerly flow is often accompanied by a rise in sea-level pressure, lower temperatures, coastal stratus, and fog. The mesoscale disturbance responsible for this southerly transition has become known as a coastally trapped wind reversal (CTWR). While it is clear that these mesoscale disturbances are forced by the interaction of the coastal topography with the synoptic-scale flow, the exact mechanisms for their development and their governing dynamics remain the subject of much debate.

The present study examines three cases from 1996 that appear to have the characteristics of a CTWR. Each case is analyzed to determine the associated synoptic-scale forcing and the respective mesoscale structure. The observed synoptic-scale forcing is compared to the results of a climatological study conducted by Mass and Bond (1996). Results from a modeling study by Skamarock et al. (1998) are used to create a conceptual model for comparison with the observed development and mesoscale structure of each case. The results of this study show that only two of the cases can be classified as a CTWR. The study also shows that variability exists in the synoptic-scale forcing associated with the initiation of a CTWR. Two mechanisms for the development of the offshore mesoscale low, and ultimately the CTWR, have been identified. The variability in the mesocale structure of each CTWR is also documented.

DoD KEY TECHNOLOGY AREA: Battlespace Environments

KEYWORDS: Coastal Meteorology, Environmental Effects